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ABSTRACT

A synthesis of findings from 38 studies on group-based applications of mastery learning strategies are presented. Meta-analytic procedures were used to combine the results of the studies and to calculate overall estimates of the effects of group-based applications. Results show that such applications yield consistently positive effects on both cognitive and affective student learning outcomes, and several teacher variables. However, variation in the size of the effect across studies is quite large. Effect size was found to vary as a function of the grade level of students, the subject area to which mastery learning is applied, and the duration of the study. Possible explanations for this variation are discussed, along with implications for future directions in the research. Tables, figures, and a 10-page reference list are appended. (Author/PN)

A SYNTHESIS OF RESEARCH ON GROUP-BASED MASTERY LEARNING PROGRAMS

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Abstract

This paper presents a synthesis of findings from 38 studies on group-based applications of mastery learning strategies. Meta-analytic procedures were used to combine the results of the studies and to calculate overall estimates of the effects of group-based applications. Results show that such applications yield consistently positive effects on both cognitive and affective student learning outcomes, and several teacher variables. However, variation in the size of the effect across studies is quite large. Effect size was found to vary as a function of the grade level of students, the subject area to which mastery learning is applied, and the duration of the study. Possible explanations for this variation are discussed, along with implications for future directions in the research.

A Synthesis of Research on Group-Based Mastery Learning Programs

Mastery learning is a theory about the teaching-learning process that is closely tied to a set of instructional strategies. The theory of mastery learning is based on the very simple belief that <u>all children can learn</u> when provided with conditions that are appropriate for their learning. The instructional strategies associated with mastery learning are designed to put that belief into practice in modern classrooms.

Current applications of mastery learning are generally based on the ideas outlined by Benjamin S. Bloom in his article "Learning for Mastery" (Bloom, 1968). But the basic tenets of mastery learning were described in the early years of the twentieth century by Washburne (1922) and Morrison (1926), and can be traced to such early educators as Comenius, Pestalozzi, and Herbart (Bloom, 1974). In recent years mastery learning has received increased attention from educational researchers and practitioners alike. Research studies on the quality of instruction and highly effective schools consistently point to elements of mastery learning as an integral part of successful teaching and learning (Brophy, 1979, 1982; Leinhardt & Pallay, 1982). In addition, reports from school systems throughout the United

States and around the world show that the implementation of mastery learning can lead to striking improvements in a wide range of student learning outcomes (Block & Burns, 1976).

The increased attention brought to mastery learning has resulted in some confusion, however. The term "mastery learning" is today applied to a broad range of educational programs and curricula, many of which bear little or no resemblance to the ideas described by Bloom and then refined by Block (1971), Block and Anderson (1975), and most recently by Guskey (1985a). Furthermore, there is frequently confusion between the "Learning for Mastery" model described by Bloom (1968) and the "Personalized System of Instruction" model described by Keller (1968).

Bloom's and Keller's approaches to mastery share a number of common elements. For example, both require that learning objectives be well defined and appropriately sequenced; both emphasize that student learning be regularly checked and immediate feedback be given; and both stress that student learning be evaluated in terms of criterion-referenced, rather than norm-referenced standards. However, there are several major differences between the two approaches. As outlined in the writings Block (1974), Block and Burns (1976), Stice (1979), and Swanson and Denton (1977), the two are most clearly differentiated by the basis and pace of instruction each prescribes.

The personalized system of instruction model (PSI) is an <u>individually-based</u>, <u>student-paced</u> approach to instruction in which students typically learn independently of their classmates. In a PSI classroom students generally work at their own pace and move on to new material only after they have demonstrated perfect mastery of each unit. The teacher's role in a PSI classroom is primarily to give individual assistance when needed. Occasional class presentations are seen as vehicles of motivation rather than sources of critical information. Therefore, carefully designed, self-instructional materials are essential to a successful PSI program (Kulik, Kulik, & Cohen, 1979; Thompson, 1980).

The mastery learning model, on the other hand, is typically a <u>group-based</u>, <u>teacher-paced</u> approach to instruction in which students learn, for the most part, in cooperation with their classmates. Mastery learning is designed for use in typical classroom situations where instructional time and curriculum are relatively fixed, and the teacher has charge of twenty-five or more students. In a mastery learning classroom the pace of the original instruction is determined primarily by the teacher. Support for this idea comes from studies that show that many students, particularly younger students in the elementary grades and those with lower entry-level skills, lack the sophistication and motivation to be effective self-managers of their own learning (Mabee, Niemann, & Lipton, 1978; Reiser, 1980; Ross & Rakow, 1981). Thus the role of the teacher is that of an instructional leader and learning facilitator who directs a variety of group-based instructional methods together with accompanying feedback and corrective procedures.

In 1976, Block and Burns reviewed the results of carefully constructed studies on each of these approaches to mastery (Block & Burns, 1976). They found that while neither approach seemed to yield the large effects on student learning that their advocates proposed were possible, both did lead to consistently positive effects. In quantitative terms, both approaches usually produced greater student learning than nonmastery approaches, and both usually produced relatively less variability in that learning. Furthermore, both approaches appeared to yield positive effects on student affective variables, although these results were generally limited to measures taken over very brief time periods.

Kulik, Kulik, & Cohen (1979) followed-up the Block and Burns (1976) review by conducting a meta-analysis (Glass, 1976) of outcome studies of Keller's personalized system of instruction. The studies they considered all employed an individually-based, student-paced approach to mastery. In analyzing the results of 75 well-designed comparative studies, they found that PSI generally did produce higher levels of student achievement, less variation in achievement, and higher student ratings of college courses. However, their analysis also showed that the implementation of PSI did not appear to affect college course withdrawal rates or college students' study time.

Since the Block and Burns (1976) review, the literature on group-based, teacher-paced approaches to mastery has grown dramatically. Much has been written about the mastery learning process, programs have been designed and implemented to utilize these ideas, and a multitude of studies have been conducted to assess the effects of this approach.

The purpose of this article was to synthesize and summarize the results of this now rather large collection of well-designed, outcome-based mastery learning studies. Meta-analysis techniques (Glass, 1976; Glass, McGaw, & Smith, 1981) were used to synthesize the results of these studies in order to answer several major questions about group-based mastery learning programs. Specifically, we sought to determine: How effective is the typical group-based mastery learning program? What types of educational outcomes are affected by the use of mastery learning? Do programs vary in their effectiveness depending upon the grade level or age of the students involved? Are programs more or less effective depending upon the subject matter to which they are applied? Does the duration of the study effect the magnitude of the results attained?

Method

In this section we describe our procedures for locating studies and quantifying study outcomes.

Locating Studies

The first step in this research synthesis was to collect a large number of studies that examined the effects of group-based mastery learning programs. The collection process began with the search of three library data bases through the DIALOG Online Information Service. The data bases were Dissertation Abstracts; ERIC, a data base on educational materials from the Educational Resources Information Center, consisting of files from Research in Education and Current Index to Journals in Education; and Psychological Abstracts. We also manually searched Mastery Learning: A Comprehensive Bibliography, prepared by G. M. Hymel (1982) for studies that might have been missed in the computer search. Since the Block and Burns (1976) review was judged to be a fairly complete summary of the research conducted up to that point in time, we focused our search on articles and manuscripts that appeared after 1975.

These biographical searches yielded the titles of over one thousand articles that might have been relevant for our purposes. On the basis of information about the articles contained in the titles and abstracts, we reduced the initial collection of articles to 234 potentially useful articles. Those eliminated from consideration were mainly theoretical or descriptive articles that contained no quantitative analyses or study results.

Efforts were then made to obtain complete copies of all selected articles and manuscripts. In some cases, however, this proved to be extremely difficult. For example, doctoral dissertations were very difficult to obtain, and dissertation abstracts seldom provided sufficient quantitative data to be useful in our synthesis. Furthermore, a number of the papers and reports cited in Hymel's (1982) bibliography and in the reference lists of other mastery learning articles were not contained in the ERIC system. Given these limitations, were able to obtain complete copies of 144 articles and manuscripts.

Each of these articles and manuscripts was then read in full and evaluated in terms of three criteria for inclusion in our synthesis. First, to be useful for our purposes, the studies had to involve applications of mastery learning that were clearly group-based and teacher-paced. That is, we included only studies in which it was evident that students progressed through an instructional sequence as a group and at a pace determined primarily by the teacher. Second, studies had to report data on measured outcomes for students (or teachers) in mastery learning and in control classes, or have a clear time-series design. Studies without control groups, without a clear time-series design, and those that included only anecdotal reports of outcomes were excluded. Third, the studies had to be free from serious methodological flaws. For example, we eliminated studies in which treatments were not randomly assigned to intact classes.

In addition, guidelines were established to assure that each study was counted only once in the synthesis. When several different articles or manuscripts described the same study, we used the most recently published version of that study. This occurred most frequently with doctoral dissertation results and with papers presented originally at professional meetings that were later published in professional journals. When a single article reported results separately for different subgroups of students, the findings were pooled to obtain a single composite result. However, subgroup results were considered separately in follow-up analyses exploring subject area and grade level differences. The use of these guidelines kept studies with many different subgroups from disproportionately influencing the results.

Most of the articles and manuscripts read failed in one way or another to meet the criteria we established for our synthesis. A total of 38 studies did meet these criteria, however, and were included in our final pool of studies.

Quantifying Outcomes

The 38 studies included in our synthesis contained findings on program effects in five areas: student achievement, student learning retention, time variables (including measures of time-on-task and time spent), student affect, and teacher variables. Of course, student achievement was the primary variable of interest in the vast majority of studies.

Thirty-five studies reported program results in terms of student achievement outcomes. The most common measure of achievement utilized in these studies was students' scores on unit or course examinations. Typically these examinations were prepared by teachers or course instructors, and only rarely was any information given in a study regarding the validity or reliability of these instruments. Occasionally examinations were prepared by the researchers conducting the investigation, as in the studies by Block (1972) and Mevarech (1981). In a few instances results from standardized achievement tests were employed, such as the studies by Jones & Monsaas (1979), Omelich and Covington (1981), and Slavin and Karweit (1984).

Letter grades attained by students were the second most common measure of student achievement. Generally these were reported as simply distributions of A through F grades in both mastery and control classes, as in the study by Jones, Gordon, & Schechtman, 1975. In several other studies grades were reported in the form of mastery and control class grade-point averages (e.g. Clark, Guskey, & Benninga, 1983; and Guskey, Benninga, & Clark, 1984). When both examination scores and grade distributions were reported in a study, examination scores were used in quantifying study results since these were believed to be the more objective index of achievement effects.

Four studies measured student learning retention over time (Anderson, Scott, & Hutlock 1976; Block, 1972; Omelich & Covington, 1981; Wentling, 1973). In all but one case this was accomplished by retesting students on the learned material two to four weeks after instruction on the material had been completed. The one exception was the Anderson, Scott, & Hutlock (1976) study in which students were retested four months after instruction was completed.

Time-related variables were measured in eight of the studies. The majority of these studies employed measures of student involvement in instruction or time-on-task. However, a study by Arlin and Webster (1983) explored differences in the amount of time spent in learning under mastery learning conditions. In addition, a study by Clark, Guskey, and Benninga (1982) looked at the effects of mastery learning on college students' class attendance, and an evaluation study ~~by~~ Guskey and Monsaas (1979) considered mastery learning's effects on college course attrition rates.

A wide range of student affective variables were explored in this collection of group-based mastery learning studies, including affect toward the subject (Anderson, Scott, & Hutlock, 1976; Block & Tierney, 1974; Blackburn & Nelson, 1985), grade expectations (Denton, Ory, Glassnap, & Poggio, 1976), and attribution assignments (Duby, 1981; Guskey, Benninga, & Clark, 1984). Finally, several studies investigated mastery learning's affect upon particular teacher variables, such as teachers' expectations for student learning (Guskey, 1982), teachers' attribution assignments (Guskey, 1984, 1985b), and their attitudes toward the mastery learning process (Okey, 1977).

To quantify the outcomes of these studies we used the <u>effect size</u>, defined as the difference between the means of the treatment and control groups divided by the standard deviation of the control group (Glass, 1976). For studies that reported means and standard deviations for both treatment and control groups, we calculated the effect size from the data provided. For time-series designs and for less fully reported studies, we calculated the effect size from such statistics as t or F, using procedures described by Glass, McGaw, and Smith (1981) and Hedges and Olkin (1985).

Results

The results of our quantification of study outcomes are illustrated in Table 1. In this section we report our synthesis of these results for each of the five types of outcomes separately.

Insert Table 1

Student Achievement

All of the 35 studies that reported measures of student achievement showed positive effects as a result of the application of group-based mastery learning strategies. While in some studies the size of the effect was relatively modest, in no study did students under control conditions perform better than those under mastery conditions. In a few studies students in control classes in a particular subject area were found to do better than students in mastery classes (e.g. Guskey & Monsaas, 1979; Wire, 1979; Wortham, 1980). However, when these results were pooled with results from other subject areas within the same study, the overall effect consistently favored the mastery group.

Although all studies measuring achievement outcomes yielded positive effects, the size of the effect was found to vary considerably. This variation is illustrated in Figure 1. The overall achievement effect size for the 35 studies we considered ranged from .02 (Slavin & Karweit, 1984) to greater than 1.70 (Arlin & Webster, 1983; Burrows & Okey, 1975). In fact, the distribution of effect sizes was so diverse that calculation of a measure of central tendency describing the typical effect size from the application of group-based mastery learning strategies was deemed inappropriate.

Insert Figure 1

To explore possible explanations for this tremendous diversity of effect sizes, we grouped the studies along three dimensions and calculated pooled effects within these groupings. Studies were grouped first by the grade level of the students involved in the study, second by the subject area to which the mastery learning strategies had been applied, and third by the length of the application or duration of the study.

The results of grouping the studies by the grade level of the students involved are shown in Table 2. Studies involving students in grades 1-8 were classified as elementary; those with students in grades 9-12 were considered high school studies; and those involving students in post-secondary classes were classified as college level. These results indicate that although the effects of group-based mastery learning strategies are positive across all levels of education, they appear to be larger for younger students in elementary classrooms than for older high school or college students. The average effect size for studies involving elementary students was .94. Studies involving high school students had an average effect size of .72, while those involving college level students had an average of .65. A test of these differences showed that they were, indeed, statistically significant.

Insert Table 2

One possible explanation for these differences across grade levels relates to the theoretical underpinnings of mastery learning. In outlining the theory of mastery learning, Bloom (1976) emphasized that students' <u>cognitive entry behaviors</u> bear a very strong influence upon their learning. That is, the academic preparation and learning history students bring with them to a teaching-learning situation can have a powerful effect on the level of achievement they attain. This history determines the cognitive skills and abilities students bring to the classroom. It also influences how they feel about learning and about themselves as learners. Elementary school students enter classrooms with a learning history that is much less extensive than that of high school or college students. Hence the potential of mastery learning, or any strategy designed to improve students' level of achievement, is theoretically far greater in the elementary grades where acquired learning deficiencies are likely to be easier to overcome. Finding that the effects of mastery learning are larger in studies conducted at the elementary level may thus simply confirm that theoretical premise.

Another possible explanation is that group-based mastery learning strategies are simply more effective for learners or the learning conditions that typically exist in elementary classrooms. As mentioned earlier, several studies have shown that students in the early elementary grades generally need more direct guidance from their teachers to establish an appropriate learning pace. The fact that group-based approaches to mastery learning explicitly provide that guidance may explain the larger effects at this level.

Table 3 shows the results of grouping the studies by the subject area to which mastery learning was applied. Studies grouped under science include classes in general science, biology, and chemistry. Mathematics studies included basic math, general math, consumer math, algebra, matrix algebra, fractions, geometry, and graphs. Those studies grouped under social studies included economics, government, history, humanities, and general social studies. Classes involving English, grammar, reading, vocabulary, and foreign language were grouped under language arts. Since studies involving the application of mastery learning in several subject areas could be counted more than once, the total number of studies indicated in this table is larger than that shown in Table 2.

These results again illustrate the positive effects of group-based mastery learning strategies in all subject areas. Nevertheless, there do appear to be subject area differences and tests showed that these differences were statistically significant. Applications involving science produced an average effect size of .49. However, applications to instruction in mathematics, social studies, and language arts yielded more positive effect sizes ranging from .72 to .77.

Insert Table 3

These findings are not altogether what mastery learning theorists typically predict. Bloom (1976) and Block (1971) both suggest that while mastery learning procedures are likely to enhance learning outcomes in most all subject areas, effects will probably be largest in mathematics and science. After all, learning in these subject areas is generally more highly ordered and sequential. An instructional process based upon having students attain a high learning standard in each unit of an instructional sequence would thus seem particularly promising in these subjects.

It may be, however, that the ordered and sequential nature of learning in science is generally recognized by most science teachers and, as a result, instruction in science classes more frequently incorporates elements of the mastery learning process already. Instruction in social studies and language arts, on the other hand, is generally less ordered and sequential. Learning objectives in these subjects are usually less well-defined, the best or most appropriate sequence of objectives is less clear, and procedures for evaluating students' learning are typically more subjective. Therefore, to incorporate mastery learning in instruction in social studies and language arts probably requires greater effort and greater change in instructional procedures. At the same time, however, the evidence indicates that these changes typically result in very positive effects on student learning.

An alternative explanation for these results rests again in grade level differences. In the studies we considered, group-based applications of mastery learning to instruction in science took place primarily in upper grades; that is, in high school and college level science classes. In fact, this was true in eight of the nine studies that measured effects in science-related subjects. Hence, the smaller effect size in science may be due principally to grade level differences as discussed earlier, than it is to any particular aspect of teaching and learning in science. This was also verified by a statistically significant test of a subject by grade interaction.

Finally, studies were grouped by the duration of the study or the length of time mastery learning procedures were applied. Studies lasting only one week were grouped together; studies lasting two to twelve weeks were placed in a second group; and studies lasting eighteen weeks (the typical college semester) or longer were placed in a third group. No well-designed longitudinal studies were found that investigated the effects of mastery learning when employed over several years, although a few are presently underway (e.g. Vickery & Suarez, 1985). The results of grouping the studies by study length are shown in Table 4.

Insert Table 4

This grouping of studies showed that study duration also appears to influence the size of the effect. Studies lasting only one week had an average effect size of .93. However, studies lasting two to twelve weeks and those lasting eighteen weeks or more had an average effect size of

.76 and .74, respectfully. These differences again proved to be statistically significant.

There are several possible reasons for studies of shorter duration having larger effects. One is that the studies lasting only one week may have been subject to a Hawthorne effect in which simply the novelty of the mastery learning instructional format led to positive results. A second and more probable reason is that the studies covering only one week of instruction typically involved learning about a topic that was new and unfamiliar to nearly all students. For example, several of Anderson's studies (1975a, 1975b, 1976) involved teaching eighth grade students the basic operations of matrix algebra, a topic in which they had little or no previous knowledge. Similarly, Arlin and Webster (1983) employed a unit on sailing and purposefully omitted from the results those students who had previous knowledge of the topic. By selecting topics that were new and unfamiliar to students, these researchers minimized the influence of any previous learning in that area. In other words, learning these topics would be less influenced by the cognitive entry behaviors students bring to the teaching-learning situation. However, while this allows for a cleaner test of the effects of the instructional process, it also restricts generalization of the results.

Studies lasting two weeks and longer, on the other hand, typically involved the introduction of mastery learning procedures to more general subject areas in regular classes. While this certainly broadens generalizability, the strong influence of students' cognitive entry behaviors is also likely to limit the potential of the mastery learning procedures to bring about improvements in students' learning.

A third possible explanation for these results is that differences in study duration also reflect a difference in study purpose. The central question explored in studies lasting for several weeks seemed to be, "What improvement in learning is <u>typical</u> through the introduction of mastery learning procedures." Hence, these studies generally involved instruction over a variety of topics as it takes place in typical school settings. In studies lasting only one week, however, the central question seemed to be, "What improvement in learning is <u>possible</u> through the use of mastery learning procedures." In other words, while studies lasting several weeks sought to determine what was most likely, the studies lasting only one week sought to explore the potential of mastery learning under more ideal conditions. This difference in purpose, coupled with the greater experimenter control and methodological rigor that generally accompanied the studies of shorter duration, may account for these differences in effect size.

Student Retention

Four studies were found that investigated students' retention of learned material over time. A study by Block (1972) measured eighth grade students' retention of the material from a brief unit on matrix algebra two weeks after they had completed the unit. The effect size favoring students taught under mastery conditions was found to be .62. Omelich and Covington (1981) compared the learning retention of college students taught introductory psychology by mastery versus nonmastery procedures. They retested students four weeks after completion of the course using criterion-referenced instruments and found a positive effect of .73. In a study by Wentling (1973), high school students were retested on their knowledge of material they had learned three weeks earlier in a course in automobile mechanics. Again, mastery taught students performed far better on this retention test than students taught under nonmastery conditions, the effect size being .51. The only study that investigated long-term retention was a study by Anderson, Scott, & Hutlock (1976) in which students were retested on their retention of the material four months after completing instruction. The retention of mastery students was again found to be significantly greater, with an effect size of .52.

The results of these studies show that group-based mastery learning strategies do appear to have a positive effect upon students' retention of the material they learn, although not quite as large an effect as upon initial levels of achievement. The average effect size for retention across studies was .62. A limitation of these studies, however, is that all but one measured retention over relatively short time periods. Well-designed studies that measure long term retention over a period of months or a year are definitely needed.

Time Variables

Variables related to time were investigated in several studies of group-based mastery learning strategies. The variable most frequently considered in these studies was academic engaged time or time-on-task. The five studies that included data on time-on-task all gathered these data through very similar techniques involving classroom observations of students. In most cases, researchers observed a random sample of students at regular intervals during the time the students spent in class and recorded their overt behaviors as either on- or off-task. Comparisons between mastery and nonmastery classes yielded a positive average effect size across the five studies of .68.

Two other time-related variables considered in evaluation studies of group-based mastery learning programs were student attendance and course attrition rates. We considered these to be time variables because of their direct relation to academic engagement and persistence or perseverance. Clark, Guskey, and Benninga (1983) assessed differences in college students' attendance in undergraduate education classes taught by mastery and nonmastery approaches. They found statistically significant differences between class sections favoring the mastery groups, with an effect size of .38. Guskey and Monsaas (1979) used course attrition rates as an outcome measure in a comprehensive evaluation of a mastery learning program begun in an eight-campus, community college system. Their evaluation involved over 2000 students enrolled in seventy-seven different class sections. In seven of eight academic disciplines, attrition rates were lower in classes taught by mastery learning, with an average effect size of .85. This is in sharp contrast to the results from summaries of PSI studies in which course attrition rates have generally been found to increase (Block & Burns, 1976) or be unaffected (Kulik, Kulik, & Cohen, 1979). Perhaps the teacher-paced aspect of group-based mastery learning strategies helps avoid the high level of student procrastination that is common in most student-paced PSI programs and responsible for many course withdrawals.

A final time-related variable that has received increased attention in recent mastery learning studies is <u>time spent</u>. Interest in this variable stems from early writings on mastery learning and specifically Bloom's (1971) notion that under more appropriate instructional conditions, students become more similar in their level of achievement and also their learning rate. That is, the differences between the fastest and slowest learners in the time they need to learn certain content to a specified criterion begin to diminish. Bloom further suggested that mastery learning might be one way to offer the vast majority of students these more appropriate instructional conditions. It was his belief that through procedures such as those offered by mastery learning, students' learning rates could be altered and slow learners could be helped to become faster in their learning. Two early studies by Anderson (1975a, 1976) offered evidence that Bloom's notion was indeed accurate.

In several recent studies and reviews, however, Arlin (1982, 1984a, 1984b) challenges this notion, arguing that learning rate is a fairly stable and unalterable student characteristic. He suggests that the positive gains evidenced in most mastery learning programs come mainly from continually providing greater amounts of learning time for students who are experiencing problems or difficulties. Since this time must come from somewhere, Arlin argues that learning in other areas or other subjects must be sacrificed to gain these results.

In a study investigating this issue, Arlin and Webster (1983) had seventh grade students learn about sailing through self-instructional modules for four days under mastery and nonmastery conditions. Although mastery students achieved at a much higher level than nonmastery students (achievement effect size = 3.04), they also spent significantly more time in learning (time spent effect size = 3.11), indicating that achievement gains may indeed be attributable to simply greater amounts of time being spent. Yet because this study lasted only four days it is also possible that a reduction in time differences did not have sufficient opportunity to occur.

In another study that lasted two weeks, however, Arlin (1984a) followed the progress of elementary students in mastery learning classes over ten instructional units. Based on an analysis of data on remedial time and the number of students needing remedial time in each unit, Arlin concluded that "differences between fast and slow learners remained stable across time," and "the extra time needed to bring slower students to mastery remained stable across the course of time." (p. 116). But a close inspection of the study results indicates these conclusions may be ill-founded.

Figure 2 shows a plot of the data on remedial time needed over instructional units for the four classes included in Arlin's (1984a) study. Results from units 1 and 10 are not shown since these were review units and, for that reason, excluded in Arlin's analysis. Figure 3 illustrates the same plot of remedial time over units, combining the results from the four classrooms. The precise data points shown in this figure are listed in Table 5. As this graph clearly illustrates, the amount of remedial time needed to bring students to a mastery criterion <u>decreased</u> over instructional units. In fact, the amount of remedial time needed in unit 9 was only one-fourth what was needed for unit 2, indicating that the difference between fast and slow students did, indeed, diminish. Although this statistically significant linear reduction in remedial time was identified by Arlin, it was largely ignored.

Insert Figures 2 & 3

The graph shown in Figure 4 illustrates a plot of the ratio of total teaching time to original teaching time, again over instructional units for the four classes included in Arlin's (1984a) study. In this ratio, total teaching time is equal to the original teaching time plus remedial time. Hence, this ratio is comparable to the proportion of additional time required to bring students to a mastery criterion, adjusting for differences in the difficulty of the unit. The jump in the scores of classes 3 and 4 on unit 5 resulted because this unit was a review unit, presumably covering a cumulation of the material taught in units 1 through 4. Figure 5 shows these same data combined across classrooms. The precise data points for this combination are also listed in Table 5. Although the trend in the data shown in Figure 5 is not statistically significant, it is clearly in a direction supportive of Bloom's notion. In fact, the ratio of total time to original time in unit 9 represents a twenty-six percent reduction from that of unit 2 in just a two week period.

Insert Figures 4 & 5

Insert Table 5

It thus appears that Arlin may be guilty of the same "selective interpretation of evidence" of which he accuses certain mastery learning advocates (Arlin, 1984b, p. 81). This evidence, along with that presented in Anderson's (1975a, 1976) studies, suggests that differences between fast and slow learners do decrease under mastery learning. That is, learning rate does appear to be an alterable characteristic and mastery learning procedures may be one way slow learners can be helped to increase the rate at which they learn.

Evidence on ways to accommodate <u>initial</u> differences in students' learning rates are less definite, however. Clearly the introduction of mastery learning compels many, and perhaps most students to spend additional time in learning activities. But it is less clear whether this time must come from that previously allocated to learning in other subject areas, as suggested by Arlin (1984b) and Slavin and Karweit (1984), or whether it can be gained by encouraging students to spend a greater portion of their school time actively engaged in learning, as suggested by Block (1983) and Guskey (1983). Evidence supporting the latter of these two perspectives was provided in a recent study by Fitzpatrick (1985) in which it was demonstrated that under mastery learning, time for instruction is utilized more purposefully by both teachers and students, the time spent in transitions between instructional events and in non-academic interactions is decreased, and the rate of student off-task behavior is dramatically reduced. Still, additional studies that include systematic procedures for gathering data on time allocations and learning rates are needed.

Student Affect

Measures of student affective variables were included in six of the studies on group-based mastery learning strategies that we considered. However, because these studies tapped such a wide range of affective indicies, calculation of an average effect size for affective outcomes was judged inappropriate. The variables assessed in these investigations included students' affect toward the subject they are studying (Anderson, Scott, & Hutlock, 1976; Block & Tierney, 1972), their feelings about the importance of the subject (Blackburn & Nelson, 1985), their academic self-concept (Anderson, Scott, & Hutlock, 1976), their grade expectations (Denton, Ory, Glassnap, & Poggio, 1976), and their attributions for learning outcomes (Duby, 1981; Guskey, Benninga, & Clark, 1984). Results from these studies indicate that mastery learning procedures have an overall positive effect on affective outcomes, though typically not as large an effect as what they have on cognitive outcomes. Students who learned under mastery conditions generally liked the subject they were studying more, were more confident of their abilities in that subject, felt the subject was more important, and accepted greater personal responsibility for their learning than students who learned under nonmastery conditions. Effect sizes for these affective outcomes ranged from .11 to .53. The one exception to these positive results was the slightly negative effect upon grade expectations identified in the Denton, Ory, Glassnap, & Poggio (1976) study in which the effect size was -.05. Apparently because students in mastery classes receive very regular and specific feedback on their learning progress, their grade expectations may be more accurate but somewhat lower than the typically inflated grade expectations of students in classes taught by other methods.

Two issues need to be kept in mind in interpreting these findings. The first is that all of these studies assessed affective change over relatively short periods of time and did not include follow-up measures on affective outcomes. Because affective characteristics in students can be very difficult to alter in a short time, studies conducted over more extended time periods could potentially yield even larger effects on these and other affective variables. On the other hand, it may be that these favorable results are also attributable in part to a Hawthorne effect. In other words, the novelty of the mastery learning procedures might have led to temporary expressions of enthusiasm. If so, studies of longer duration could yield smaller effects. Clearly, additional studies that consider affective outcomes over extended periods of time are needed.

Teacher Variables

A final area of outcomes investigated in several studies of group-based applications of mastery learning is its effects upon teachers. Four studies were located that specifically measured these effects. In general, these studies focused on how teachers react when they begin using mastery learning and, as a result, see more of their students learning well and attaining higher levels of achievement. In an early study in this area, Okey (1977) found that teachers and teaching interns expressed much more positive attitudes toward the philosophy and practices of mastery learning after they had used these practices in their elementary classrooms for only three weeks. The effect size for this attitude change was 1.67. More recently, Guskey (1982) found that teachers who successfully implement mastery learning begin to alter their expectations for students' achievement and find it much more difficult to predict which students will do well and which students will experience learning difficulties. In this study, the relationship between teachers' initial expectations for students' learning and students' final achievement approached zero. In another study, Guskey (1985b) discovered that after using mastery learning teachers alter their explanations as to why they are effective in the classroom, giving much less importance to personality factors (effect size = -.38) and far greater importance to teaching practices and behaviors (effect size = 1.13).

Finally, in a large scale study involving 117 junior and high school level teachers, Guskey (1984) found that teachers who use mastery learning and see improvement in student learning outcomes begin to feel much better about teaching and their roles as teachers (effect size = .61), accept far greater personal responsibility for their students' learning successes and failures (effect size = 1.25), but express somewhat less confidence in their teaching abilities (effect size = -.59). This seemingly anomalous finding was explained by Guskey as a "humbling effect." That is, to suddenly gain evidence that they could be far more effective in their teaching was disruptive to these teachers' confidence that they were already doing the best that was possible. No attempt was made to follow-up these teachers, however, to determine whether this "humbling effect" endured or diminished over time.

It thus appears that the successful use of mastery learning can have very powerful effects on many teacher variables. Caution must be taken in interpreting these effects, however, because not all are positive. In addition, because extended follow-up studies or long term investigations have not been conducted, we have no evidence presently as to whether these effects endure or whether they are a temporary condition resulting from the initial novelty of a new approach.

Discussion

This synthesis of research on group-based mastery learning programs supports the findings of other reviews of mastery learning's effectiveness. Like Block & Burns (1976) and more recently Walberg (1984), we found that group-based applications of mastery learning have consistently positive effects on a broad range of student learning outcomes, including student achievement, retention of learned material, involvement in learning activities, and student affect. In addition, we found that the use of mastery learning has significant effects on several teacher variables, although these effects are mixed. Our synthesis also revealed, however, that the magnitude of the effect on student achievement measures varies widely across studies and, hence, calculation of an average effect size was considered inappropriate.

Several factors were explored in an effort to account for this variation in student achievement effects. These factors included differences in the grade level of the students, in the subject area to which mastery learning strategies were applied, and in the duration of the study. While each of these descriptive factors explained a significant portion of the variation in achievement effect sizes and in combination explained 57 percent of the total variation, other less measurable factors may have influenced the results of the studies as well. For example, all of the studies included in this synthesis were conducted in actual classroom settings. The major advantage of this is it offers a more accurate estimate of the effects of mastery learning in this type of setting than is possible from studies conducted in more artificial settings, such as learning laboratories. The major disadvantage, however, is that studies conducted in actual classroom settings are subject to the many extraneous influences present in those classrooms. Differences in student characteristics, teacher characteristics, student-teacher interactions, and classroom environments may all bear some influence on study results. These influences are extremely difficult to measure or control, and may explain, at least partially, the large variation in study results.

Another factor that undoubtedly contributes to the variation in magnitude of the effects is the lack of precision in specifying the treatment. As mentioned earlier, there is confusion and debate as to what is and what is not mastery learning. This confusion involves not only the basis and pace of the instructional format, but also the essential characteristics of the feedback students are offered, the essential characteristics of the corrective activities in which they are involved, and the specific procedures used to evaluate their learning. Many of the studies in this synthesis did not include detailed descriptions of the mastery treatment (or the nonmastery control) and those which did served mainly to illustrate how widely varied that treatment can be. In addition, few studies that lasted more than one week made any attempt to precisely assess the degree of implementation of the mastery learning process or the quality of that implementation. Differences in degree and quality of implementation certainly bear strong influence on the magnitude of the effects, regardless of the methodological rigor of the study measuring those effects.

While this synthesis shows clearly that the effects of group-based applications of mastery learning are overwhelmingly positive, it also illustrates a number of gaps in the research on mastery learning where further studies are sorely needed. One such gap is longitudinal studies of mastery learning's effects. Bloom (1976) theorized that students who learn a subject under mastery learning conditions are more likely to develop the cognitive entry behaviors that are necessary for more advanced study in that subject. Therefore, they are more likely to do well in later grades or in higher level courses, even when the mastery learning procedures are not continued. A small scale exploratory study by Bonczar, Easton, and Guskey (1982) supports this notion. Still, more detailed, longitudinal studies that follow students over several years, particularly through continued applications of mastery learning procedures are definitely needed.

Another related area in need of investigation is the degree to which students who learn under mastery learning conditions develop "learning-to-learn" skills. These are skills that students can use on their own to enhance their effectiveness and efficiency in learning situations, regardless of the teacher or the instructional format. Clearly group-based mastery learning procedures help students better organize their learning, use the feedback they receive from the teacher, pace their learning, and work at correcting their learning errors. But at present we do not know whether students who experience mastery learning in one subject are able to carry over these skills to learning in other subjects or to other classes. Nor do we know the particular conditions under which the transfer of these skills can be fostered. The development of such learning-to-learn skills would seem one of the most powerful benefits of mastery learning strategies and one that we need to better understand.

A third area where additional research is needed is mastery learning's effects upon time variables. Well designed studies lasting more than a week or two that consider variation in student learning rates and how time is spent in mastery learning classes would help to answer many important questions. Furthermore, such studies are likely to have far-reaching implications not only for instruction but also for our notions about human variability and individual potential. Similarly, we need further studies on practical and efficient ways of providing fast learners in group-based classrooms with opportunities to extend their learning through rewarding and challenging enrichment activities. We need to know more about the benefits and costs of such activities and how they can be best utilized to offer these students valuable learning experiences that may not be generally available in classes taught by methods or techniques other than mastery learning.

A fourth area in need of further investigation is the degree to which the use of mastery learning alters the classroom climate, teacher-student interactions, and student-student interactions. Block and Anderson (1975) and Guskey (1985) note that teachers using mastery learning are likely to find their role in the classroom changes from that of a judge who evaluates students and places them in categories depending upon how they rank among their classmates, to that of a learning leader who works with students so that all can be successful in learning. However, this change, or its implications, has not been systematically explored. It has also been noted that students in mastery learning classrooms readily cooperate with one another and peer tutoring frequently occurs spontaneously. Mevarech (1985) and Slavin and Karweit (1984) demonstrated that cooperative learning strategies and student teaming can be easily facilitated in mastery learning classrooms. Still, additional studies investigating mastery learning's effects on these interpersonal dimensions of the classroom environment are greatly needed.

A final area which has already shown great promise but in which much work remains is ways to enhance the mastery learning process in order to gain still better results. Mevarech's (1981) study showed, for example, that the inclusion of higher order questions on the formative tests administered in a mastery learning class can significantly increase students' mastery of higher level cognitive processes and problem solving skills. Similarly, Leyton's

(1983) study demonstrated that the results attained in high school mastery learning courses can be further improved by conducting brief reviews on course prerequisite skills prior to the beginning of the course. Other potentially useful ideas have been suggested by Bloom (1984). But for the most part, these have yet to be systematically studied.

In summary, this synthesis has provided some valuable insights into the effectiveness of group-based mastery learning programs, and has also illustrated some of the strengths and weaknesses of meta-analytic procedures. Meta-analysis provided us with a useful tool in our efforts to better understand the results of a growing body of research literature on mastery learning. It did not, however, provide us with definitive answers. It helped to identify factors that seemed likely to influence study results and gave us the means to test the significance of those factors. It also helped us to identify an entire range of new research questions where further study is clearly needed. Granted, the selection criteria we employed were quite strict and may have biased the scope of our review. But we believe they were appropriate for our purposes.

Group-based mastery learning strategies show great potential and great promise. It appears they can be implemented in regular classrooms without major revisions in instructional procedures, class organization, or school policy. Still the research evidence reviewed here indicates the use of these strategies can result in significant improvements in a broad range of student learning outcomes and teacher variables. Additional studies are clearly needed, but the future of these strategies looks particularly bright.

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Table 1

Summary of Study Outcomes

Study	Level	Duration	Sample Size	Subject Matter	Learning Measure	Effect Size
Anderson (1975a)	8	1wk	39	Matrix Algebra	Exam Scores	1.12
Anderson (1975b)	8	1wk	55	Matrix Algebra	Exam Scores	1.44
Anderson (1976)	8	1wk	82	Matrix Algebra	Exam Scores	1.07
					Time-on-task	.49
Anderson, Scott, & Hutlock (1976)	1-6	36wks	390	Mathematics	Exam Scores	.58
					Retention	.52
					Subj. Aff.	.41
					Self-Concept	.49
Arlin & Webster (1984)	7	1wk	88	Sailing	Exam Scores	3.04
					Time Spent	3.11
Blackburn & Nelson (1985)	Coll.	18wks	36	Algebra	Exam Scores	1.00
					Subj. Aff.	
Block (1972)	8	1wk	91	Matrix Algebra	Exam Scores	.54
					Retention	
					Time-on-task	.26
Block & Tierney (1974)	Coll.	10wks	44	History	Exam Scores	.39
					Grades	.35
					Subj. Aff.	.27
Bryant, Payne, & Gettinger (1982)	1-4	3wks	48	Sight words	Exam Scores	1.28
Burrows & Okey (1975)	4-5	2wks	84	Geometry	Exam Scores	1.71
Chiappetta & McBride (1980)	9	3wks	99	Chemistry	Exam Scores	.52
Clark, Guskey, & Benninga (1983)	Coll.	18wks	197	Ed. Psych.	Exam Scores	.61
					Grades	.34
					Absences	.38
Denton, Ory, Glassnap, & Poggio (1976)	Coll.	18wks	396	Ed. Meas.	Exam Scores	.18
					Grade Expct.	-.05

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Dillashaw & Okey (1983)	10	18wks	156	Science	Exam Scores	.36
					Time-on-task	.76
Duby (1981)	Coll.	18wks	189	(Multiple)	Ach. Attrib.	.60
Fiel & Okey (1974)	8	1wk	90	Graphs	Exam Scores	.47
Fitzpatrick (1985)	9-12	18wks	(40t's)	Mathematics	Time-on-task	.81
Guskey (1982)	7-12	18wks	(96t's)	(Multiple)	Exam Scores	1.70
					Grades	1.80
Guskey (1984)	7-12	18wks	(117t's)	(Multiple)	Exam Scores	1.72
					Grades	.59
					Tchr. Attrib.	1.25
					Tchr. Aff.	.61
					Tchr. SC.	-.59
Guskey (1985b)	9-12	18wks	(96t's)	(Multiple)	Personality	-.38
					Behavior	1.13
Guskey, Benninga, & Clark (1984)	Coll.	18wks	122	Education	Exam Scores	.46
					Ach. Attrib.	.12
Guskey & Monsaas (1979)	Coll.	18wks	256	Biology	Exam Scores	.26
					Grades	.07
					Attrition	1.10
			67	Counseling	Exam Scores	.55
					Grades	.40
					Attrition	1.10
			250	English	Exam Scores	-.01
					Grades	-.01
					Attrition	.20
			87	History	Exam Scores	1.18
					Grades	.37
					Attrition	.90
			420	Mathematics	Exam Scores	.42
					Grades	.27
					Attrition	.40
			70	Nursing	Exam Scores	.02
					Grades	.54
					Attrition	NC
			173	Psychology	Exam Scores	.76
					Grades	.54
					Attrition	1.50
			226	Reading	Exam Scores	.85
					Grades	.35
					Attrition	.25
			57	Spanish	Exam Scores	-.55
					Grades	-.33
					Attrition	-.30

Jones, Gordon, & Schechtman (1975)	Coll.	18wks	53	Biology	Grades	.89
			44	Business	Grades	.48
			51	Chemistry	Grades	.00
			33	Economics	Grades	.89
			58	English	Grades	.86
			70	Humanities	Grades	.91
			61	Mathematics	Grades	.53
			76	Social Studies	Grades	.47
			48	Spanish	Grades	.42
Jones, Monsaas, & Katims (1978)	5-6	36wks	340	Reading	CRT Scores	.41
					ITBS Scores	.33
Leyton (1983)	10-12	4wks	128	For. Lang. Mathematics	Exam Scores	.97
Lueckemeyer & Chiappetta (1981)	10	6wks	185	Biology	Verbal Reas.	.26
					Abstract Reas.	.38
Mathews (1982)	11	4wks	234	History	Grades	.41
Mevarech (1981)	9-10	4wks	204	Mathematics	Exam Scores	.82
Okey (1974)	3-4	2wks	130	Fractions	Exam Scores	.47
Okey (1977)	5-8	3wks	180 (40t's)	Mathematics	Exam Scores	.49
					Tchr. Att.	1.67
Omelich & Covington (1981)	Coll.	18wks	425	Psychology	CRT Scores	1.49
					NRT Scores	1.49
					CRT Retention	.73
					NRT Retention	.51
Sheldon & Miller (1973)	Coll.	18wks	263	Mathematics	Exam Scores	.55
				English	Exam Scores	1.69
Slavin & Karweit (1984)	9	36wks	325	Mathematics	Exam Scores	.02
Strassler (1979)	7	5wks	93	Mathematics	Exam Scores	1.11
				Science	Exam Scores	1.64
Swanson & Denton (1976)	11-12	3wks	35	Chemistry	Exam Scores	.78

Wentling (1973)	11-12	5wks	116	Auto Mech.	Exam Scores	.38
					Retention	.51
					Time-on-task	1.07
Wire (1979)	Coll.	18wks	29	English	Grades	-.37
			40	Mathematics	Grades	.28
			57	Psychology	Grades	.46
Wortham (1980)	7-12	12wks	133	Basic Math	Grades	-.09
			61	Consumer Math	Grades	.52
			86	Government	Grades	.42
			175	Grammer	Grades	1.31
			102	History	Grades	1.09
			78	Science	Grades	.10

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Table 2

Effect Size by Grade Level

Level	Grades	No. of Studies	Mean Effect Size
Elementary	1-8	13	.94
High School	9-12	12	.72
College	13+	10	.65

Table 3

Effect Size by Subject Area

Subject Area	No. of Studies	Mean Effect Size
Science	9	.49
Mathematics	20	.72
Social Studies	8	.72
Language Arts	9	.77
Psychology	4	.83

Table 4

Effect Size by Duration of the Study

Duration	No. of Studies	Mean Effect Size
1 Week	6	.93
2-12 Weeks	14	.76
18+ Weeks	15	.74

Table 5

Data from Arlin (1984a) Averaged Across Classrooms

Instructional Unit	Remedial Time (minutes)	Total/Original Time
2	24.6	1.85
3	16.0	1.71
4	15.2	1.49
5	14.7	1.78
6	11.3	1.57
7	13.1	1.54
8	12.8	1.54
9	6.9	1.37

Figure 1

Figure 1. Distribution of achievement effect sizes

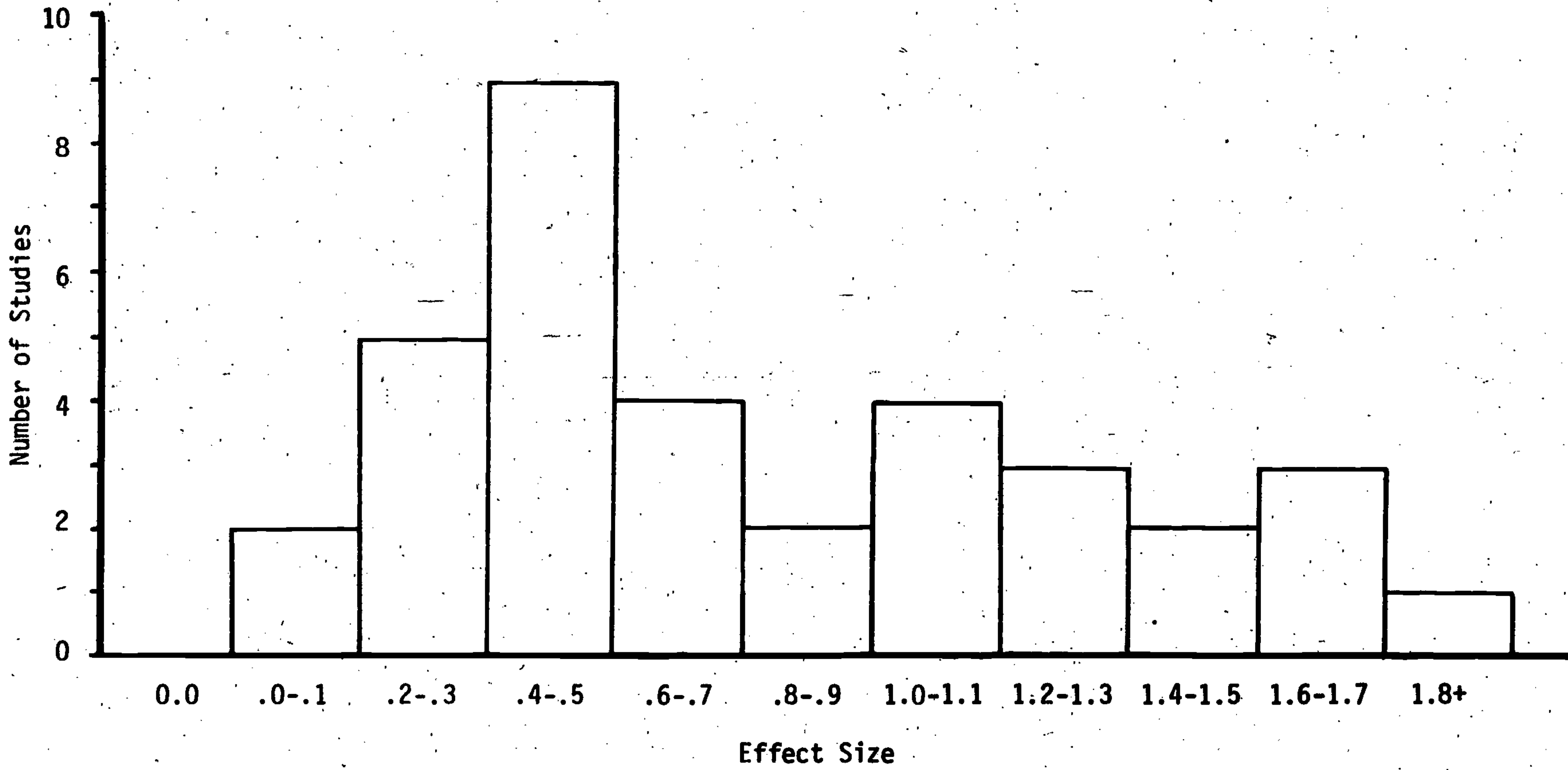

Figure 2. Remedial time per instructional unit for four classrooms (Arlin, 1984a)

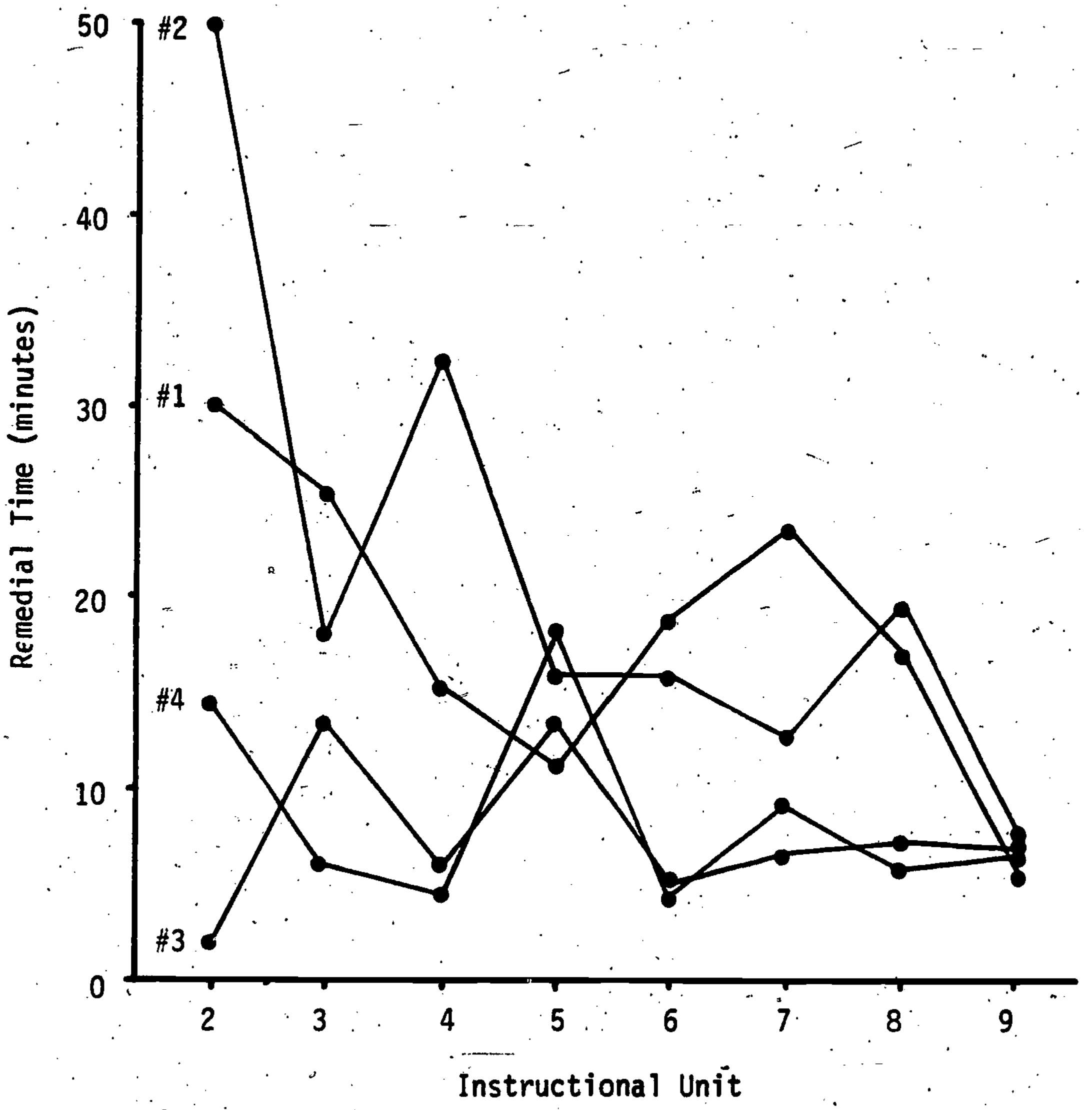

Figure 3. Average remedial time per instructional unit (Arlin, 1984a)

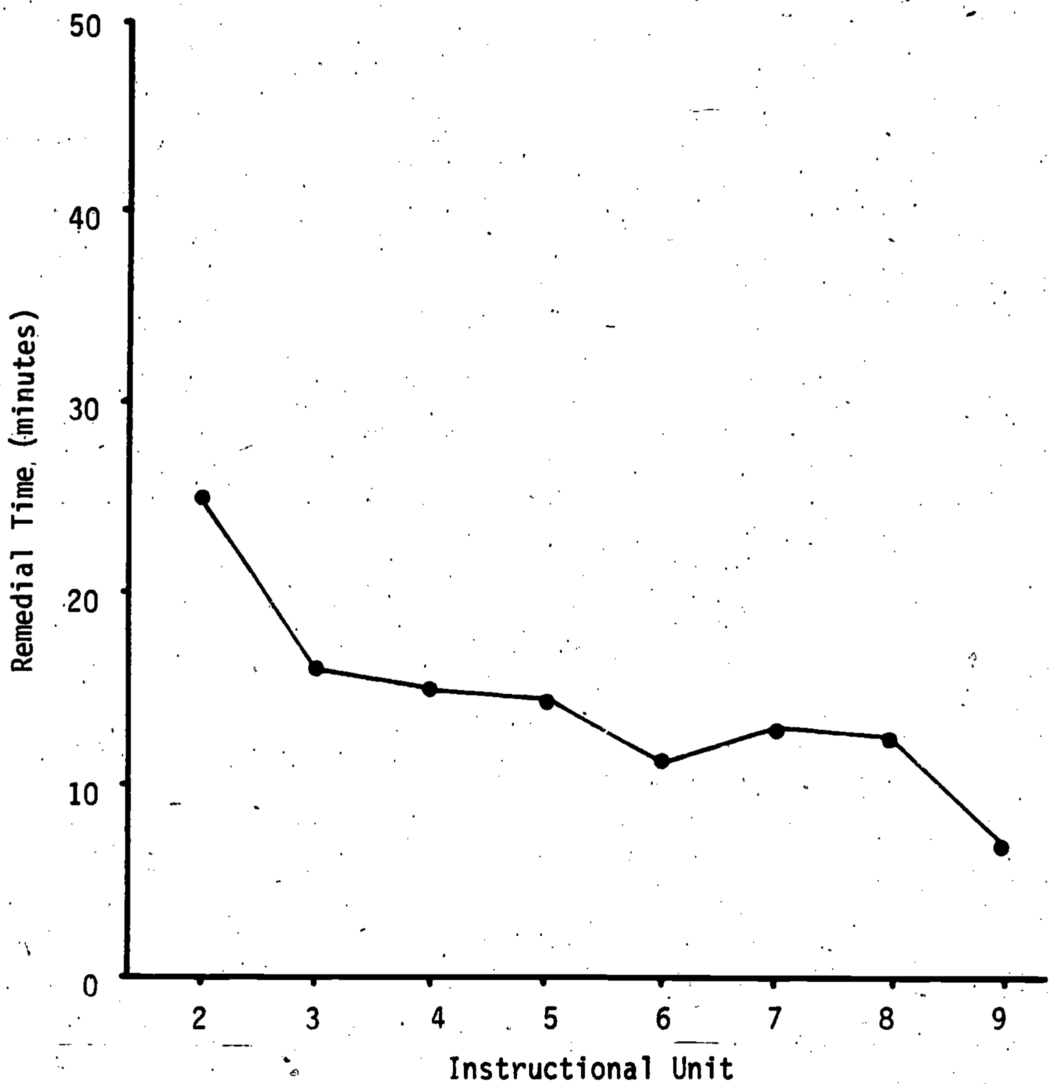

Figure +

Figure 4. Ratio of total time to original instructional time per unit for four classrooms (Arlin, 1984a)

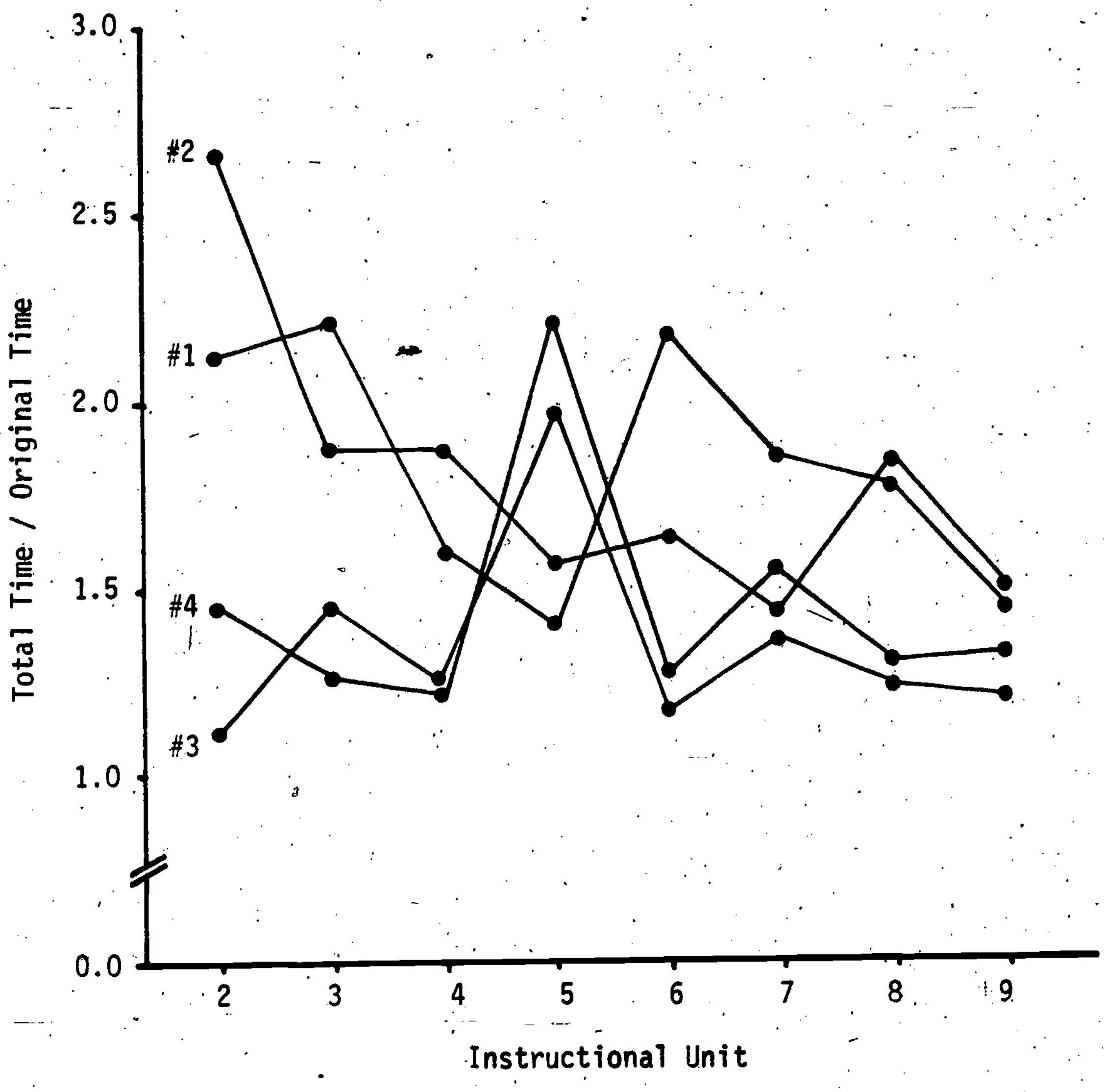

Figure 5. Average ratio of total time to original instructional time per unit (Arlin, 1984a)